A more realistic peacetime risk is rapid price escalation. Producers other than Zaire have been quite willing to go along with its price leadership when supplies are tight. In fact, other countries may have initiated some of the past increases. In the event of another artificial price boost, however, cobalt users might be less prone to make matters worse by rushing to expand stocks. While U.S. consumer stocks of cobalt are now quite low (about a month's normal consumption), dealer stocks in the United States bring the total up to about eight months.

Supply Alternatives

In the event of a supply interruption, the most important immediate insurance would consist of stocks in the United States and Belgium, and at cobalt processing facilities in Finland, Norway, Canada, and Japan. Some contingencies might leave large stocks of the metal in Zaire itself.

Secondary fallbacks would be increased concentrate or matte production in Zambia (which already has plans for further expansion), Canada, Finland, Australia, the Philippines, and other sources. Zairian copper output would be interrupted by the same contingency that affected cobalt. Further, a cobalt contingency would increase the demand for nickel, since the latter is in some measure a substitute. This would lead to greater nickel production, in which cobalt is a frequent by-product.

Ore in the Blackbird mine in Idaho contains both cobalt and copper. It has already been partially developed and could be quickly brought into full production if cobalt prices rose above $25 per pound. Consideration has also been given to reopening the Madison mine in Missouri, where cobalt can be produced in conjunction with copper, nickel, and lead, as well as to a new mine in California (Gasquet Mountain), where the cobalt is associated with nickel and chromium. The Blackbird mine alone could reduce U.S. import dependence by some 10 or 15 percent. At the current price of $5 per pound the required subsidy would be on the order of $20 per pound, or some $30 million per year for the 1.5 million pounds of potential cobalt production. Potential output of cobalt at each of the other two mines is also in the 1.5 to 2.0 million pound range.

Existing processing capacity in the United States would be insufficient to handle the additional ore. On the other hand, excess processing capacity does exist in a number of other countries, including Canada. The current worldwide excess capacity is probably enough to make up for the loss of Zairian processing. Should a supply contingency occur during a period of international economic boom, however, the availability of processing facilities would be a problem, especially if the boom were strong enough to absorb surplus stocks. Barring adequate warning, shortages could last for a year or more, unless they were counteracted by substantial releases from the strategic stockpile.

A deliberate attempt on Zaire's part to escalate prices could probably be successful only with cooperation from Zambia and others at a time of high economic activity. It would undoubtedly be met by expansion of cobalt production elsewhere. Boom times would in any event bring additional cobalt on the market, since the production of both nickel and copper would expand. In Canada, INCO (formerly the International Nickel Company) has already taken steps to recover more cobalt from its ore, doubling its total output. Finnish refined cobalt capacity has recently been increased by half, presumably in response to the last price escalation. Japan has considerable refining capacity, operating on cobalt concentrates from Australia.

Consumption Alternatives

The earlier a cobalt contingency occurred, the greater the room for maneuver. The reason, paradoxically, is that the 1978-1979 price escalation set in motion forces that soon will reduce the use of cobalt to essential levels, leaving only limited room for further adjustment. Only this past year, for example, Pratt & Whitney proved out cobalt-free alloys for critical engine parts. Though there has already been some application of ceramics and composites in high-temperature applications, worldwide burgeoning of high-temperature materials research promises many new developments for the years immediately ahead. Within the coming decade, large savings could be made in cobalt consumption simply by speeding up the pace of research, testing and certification of new materials, and further adopting metalworking methods that initially produce more nearly finished shapes, with less waste and scrap. As time goes on, the use of cobalt in structural materials will be reduced to the most essential uses, thus narrowing the scope for further saving. But with less use of cobalt, the existing national defense stockpile would, of course, stretch further.

Conservation of cobalt in cutting tools has already run much of its course. There is as yet no demonstrably practical alternative to the use of cobalt in cemented carbides, though alternatives to carbide tools exist and new tool materials may be developed. Substitution in an emergency might well mean higher material costs or reduce the efficiency of machining, mining, or drilling. Cobalt consumption for permanent magnets is sufficiently price sensitive to induce some retrogression to the use of alnico (aluminum-nickel-cobalt) magnets in goods for which they are less than essential. When more exacting requirements obtain, the use of cobalt can be reduced by combining it with samarium or other rare-earth metals.

Some room for cobalt conservation and substitution exists in both ceramics and paint production, although the quantities that can be saved are relatively minor because of the declining cobalt use in these applications. In most emergencies, conservation in the use of cobalt as a catalyst would be inhibited both by the need for more chemical and petroleum products and concurrent difficulties in obtaining other catalysts. Part of the catalytic use facilitates oil desulfurization, and would be hard to forgo unless the emergency was so acute as to cause general relaxation of air pollution standards. Omission of the catalysts would make some chemical processes impracticable and greatly increase the costs of others.

Conclusions

It could be difficult to reduce cobalt use significantly if an emergency restricted supply, especially since a number of potential substitutes might themselves be in short supply. Research and development in progress is opening up more possibilities for substitution, however. But at the same time, process readjustments stimulated by the last price escalation have decreased the margin for further rapid adjustments.

The main safeguard against sudden, short-lived contingencies is the current high level of worldwide cobalt stocks. It could take a sustained period of high international economic growth to absorb excess inventories held by producers and dealers. For sustained emergencies, there are a number of substantial alternatives to central African sources of ore, although expanded use of these sources would require the installation of additional refining facilities. For meeting either an acute or a sustained military emergency, the national stockpile provides substantial insurance, even at its current roughly 50 percent fulfillment level. If the remaining 50 percent was purchased at current spot cobalt prices, it would cost about $210 million.

MANGANESE

The United States consumed slightly more than a million tons of manganese in 1981, 98 percent of which was imported, at a cost of $270 million dollars. Manganese is essential to almost all steelmaking, and its resource base is more evenly distributed worldwide than other metals discussed in this chapter.

Uses

Like chromium, manganese ore comes in metallurgical, refractory, and chemical (including battery-making) grades. Also like chromium, the great bulk of metallurgical use is as ferroalloy--both ferromanganese and silicomanganese--and metallurgical supply is the principal supply concern. Unlike chromium, the chemical grades of manganese ore are the most exacting, but the quantities required are not large and suitable substitutes can be synthesized.

About 85 percent of manganese is used in the steel industry. The principal purpose of manganese in steelmaking is to remove sulfur; most of the manganese does not remain in the steel but comes out in the slag. It also serves as a deoxidizer. Some amounts are retained in or added to steel as an alloying element, imparting hardness. The major advantage of using manganese is its low cost. 3/ To date, there has been little reason to develop substitutes, although some alternative materials (such as, aluminum for deoxidation) are used in special circumstances.

Sources of Supply

Only a few countries have significant manganese reserves, with South Africa and the USSR holding more than four-fifths of the world total. This distribution is based on an evaluation of ore that contains enough manganese to make mining economic. The U.S. Bureau of Mines defines manganese ore as having a natural content of 35 percent or more manganese. Ores ranging down to a manganese content of 25 percent may be reported by various countries as manganese ore production, with much of this lower-grade material being upgraded by processing. Based on the official definition, the United States has no manganese production, but some manganese is in fact mined domestically as a constituent of iron-bearing ores. At somewhat higher prices, it would be profitable to mine substantially more lower-grade ore around the world, including within the United States.

South Africa accounts for about three-fourths of noncommunist world reserves, but for only about a third of noncommunist mine production. Over the three-year average of 1978-1981, the largest U.S. ore supplier was Gabon, with about 32 percent of total U.S. ore imports. South Africa, on the other hand, was the single largest U.S. supplier of ferromanganese, with 42 percent of the total. Combined with its 24 percent share of shipments of ore, South Africa supplied the United States with about 35 percent of its manganese overall. By contrast, Gabon supplied overall less than 10 percent. Sources of manganese ore and alloy for 1981 are summarized in Table 5. As with chromium, the percent imported as ferromanganese is

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3. See, for example, National Materials Advisory Board, Manganese Reserves and Resources of the World and Their Industrial Implications (1981), p. 65.

TABLE 5. SOURCES OF U.S. MANGANESE IMPORTS FOR 1981 a/

Country	Percent of Ore Imports	Percent of Ferromanganese Supply
South Africa	32.4	40.6
Gabon	30.2	--
France	--	28.4
Brazil	12.9	1.8
Australia	11.4	1.0
Mexico	8.6	6.9
Canada	--	9.3
Morocco	4.5	--
Portugal	--	4.9
Other	--	7.1

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1981.

a. Percents based on manganese content.

increasing. Over the 1978-1981 period, more than two-thirds of all manganese reached the United States in this form; a decade earlier the proportion had been only 20 percent.

Besides South Africa and Gabon, France (for ferromanganese only), Brazil and Australia figure as principal U.S. sources. The Bureau of Mines counts overall imports as 98 to 99 percent of U.S. total supply. This calculation apparently contains the small amounts produced by domestic mining, but ignores the important contribution made by slag recycling. Also, it attributes to imports the considerable releases in recent years of manganese ore from the strategic stockpile. The latter factor is now somewhat academic, however, since stockpile releases have been discontinued. Stockpile holdings of ore are currently under goal, principally because the goal has been quadrupled since 1975, although a limited amount of below-specification material remains to be disposed of.

Nature of the Risks

The risks for U.S. manganese supply are somewhat similar to those for chromite, but far less critical. Sources of ore supplies (direct and indirect) are far less concentrated, and the Soviet Union is not currently among the suppliers. Sources have varied considerably over the years. For example, in the 1950s India was the principal source of ore and the world's leading exporter. In the 1960s Brazil and Gabon became increasingly important suppliers as India diverted exports to its domestic steel industry.

As with chromium, the principal risk of manganese supply disruptions lies in the heavy and increasing U.S. reliance on a single source--South Africa--for ferroalloy. Given the greater number of alternative Western suppliers, however, with access either to domestic ore or to sources outside South Africa, the price-escalation risk is far lower. Although the same risks of instability in South Africa apply for manganese supplies as for chromium, they would not affect as great a proportion of the supply.

More flexibility exists in the types of furnaces that can be converted to produce ferromanganese than ferrochrome, thus making alternative ore sources more usable. Active blast furnaces have already been changed from the production of pig iron to ferromanganese when additional supplies of the latter were needed. Even retired blast furnaces could be used for this purpose. There are two limitations on this flexibility, however. One is the likelihood that a South African contingency would jointly affect ferrochrome and ferromanganese, thus tying up some of the alternative furnaces. The other limitation would occur if a contingency coincided with a worldwide economic boom. Then available blast furnace capacity might be entirely occupied with producing pig iron, thus eliminating the alternative of furnace conversion.

Manganese supply risks in a military conflict are similarly somewhat less than those for chromium, despite the fact that the great bulk of U.S. manganese supply comes directly or indirectly from politically vulnerable areas in sub-Saharan Africa. France, the principal ferromanganese supplier after South Africa, also depends on Gabon for ore. The risk is diminished by the relatively growing role of Brazil as an ore producer, and its increasing capacity to convert that ore into ferroalloy. Although much of this increasing output is normally used in Brazil's own steel production, it remains a relatively accessible source in an emergency.

Supply Alternatives

It would be relatively easy to increase the flow of manganese ore quickly. Deposits are widespread, and most of them can be easily mined using large-scale, open-pit methods. The United States itself has a large quantity of marginally subeconomic deposits, and there are similar additional deposits in Canada and Mexico. The U.S. processing industry tends to maintain ore stocks equivalent to about a year's consumption. The national stockpile contains two and one-half to three times the industry level, the exact multiple depending on whether below-grade material is counted.

In contrast, industry stocks of ferromanganese tend to run at only three to four months of normal consumption, and the stockpile level (and goal) is only moderately greater. Under present economic conditions, a large amount of excess blast furnace capacity exists, which could be used to produce ferromanganese from ore supplies. Excess capacity on a smaller scale may persist even into a period of economic boom, because the declining U.S. steel industry uses less of its furnace capacity. Depending on the timing of a supply contingency, this margin, plus old blast furnaces and stocks of ferroalloy, might serve to provide adequate supplies until additional furnaces could be installed. If not, the United States would have to call upon Brazil and probably India to bridge the gap. During an economic boom or military emergency, it is unlikely that Europe would have surplus ferromanganese and it, in any case, relies heavily on African sources for ore. Japanese production, while relying more importantly on Australian and Indian ores, would also tend to be fully committed under such economic or military conditions.

The huge amounts of manganese contained in old slag piles would, for all practical purposes, be unavailable as an emergency ferroalloy supplement. To the limited extent that the material could be used, it would have to be recirculated through ironmaking blast furnaces. Additional amounts of manganese could be recovered by recycling old steel scrap. This source also tends to be scarce during economic booms, however, and available amounts are constrained by the current use of scrap by the U.S. steel industry.

Consumption Alternatives

The principal consumption alternative for manganese is conservation. Because manganese is cheap, it tends to be used profligately. In large measure, the amount of manganese used in steelmaking depends on the mix of various types of furnaces. In particular, electric furnace technology requires relatively less manganese per ton of steel, and the proportion of electric-furnace steel in the United States is increasing. Another route to manganese conservation, followed by Japan, is the greater use of silicomanganese in place of ferromanganese. This practice reduces the amount of manganese lost to slag, as does electric steelmaking. The National Materials Advisory Board has estimated that unit use of manganese in steelmaking might be reduced by as much as 20 to 30 percent, 4/ but conversion to this practice would take an extensive period of readjustment.

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4. Ibid., p. 68.

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The prospects for reducing manganese consumption quickly are more limited.

Conclusions

Potential risks of disruption in U.S. manganese supply are less critical than those for either cobalt or chromite. No monopoly exists, and alternative sources of supply are more numerous. As in the case of chromium, however, a potential bottleneck could arise in the supply of the ferroalloy, because of the substantial switch from domestic to foreign production. So long as the economy is slack, large furnace capacity is available to resume ferromagnese production. Moreover, more flexibility exists than in the case of chromium to shift capacity from other uses to such production. If a contingency should occur during boom times, however, industrial and government stocks might not be large enough to cope fully with demand, pending new furnace installations.

More of the national stockpile could be held as ferroalloy than is now done. Converting all of the metallurgical ore currently on hand to ferromanganese, including nonspecification material, would probably cost about $500 million. As with chromium, the President has ordered some upgrading of the stockpiled ore to increase mobilization readiness and to provide some relief to the domestic manganese refining industry.

PLATINUM-GROUP METALS

Manganese and chromium are bought and sold by the ton. Cobalt, consumed in much smaller quantities, is bought and sold by the pound. The platinum-group (platinoid) metals, consumed in still smaller quantities, are measured by the troy ounce. In fact, their prices are high enough to qualify them as "precious" metals. Platinum itself is widely used in jewelry and is subject to speculative trading and hoarding, as an alternative to gold. As a group, the platinoid metals slightly outrank cobalt in total annual cost to the U.S. economy. Industrial use of these metals was approximately 1.9 million ounces in 1981, although total consumption (including stock-building) was about 0.5 million ounces greater. About 83 percent of these supplies were imported at a cost of $800 million.

Uses

The platinum group consists of six metals, which are the most corrosion-resistant known. Use of platinum itself is some 1 million ounces per year, only slightly higher than palladium, but more than twice as high in cost. Rhodium and ruthenium rank far behind, at less than 100,000 ounces per year. Iridium has the next smallest usage, principally in electrical applications. For example, it is used jointly with platinum in high-voltage relays. Rhodium and iridium tend to be the most expensive of the six. Osmium is the rarest and is consumed only in small quantities, mostly as an alloy of the other platinoid metals to impart additional hardness.

Increasingly, the major U.S. use of platinum itself is for catalytic converters in automobile pollution-control devices. Even in 1982--a depressed year for automobile sales--close to two-thirds went into this application. A long-standing use has been in electrical and electronic goods, mostly to provide long-term reliability in electrical contacts. Another long-standing use, as a catalyst in petroleum refining and other chemical operations, appears to be in at least temporary decline, but this may be the result of increased recycling. In both automotive and industrial catalytic uses, one or more of the other platinoid metals is used in conjunction with platinum itself, for cost-savings or other reasons.

Palladium, the other major component of the group, has long been used principally for electrical goods, which now account for almost half the total. A large part provides reliable telephone relays. The use of palladium in automotive pollution-control catalysts has increased demand. Another important use has been in medicine and dentistry. Both medical/dental and electrical applications are fairly sensitive to the relative prices of platinum, palladium, and gold.

Of the lesser platinoid metals, rhodium has lately found its greatest use in catalytic converters, although it also continues to have considerable application in the chemical, electrical, and glass industries. One of its uses is in an alloy of platinum used in devices for glass extrusion, an application that may become increasingly important with increased use of optical fibers. Ruthenium finds its greatest use in the chemical and electrical industries and osmium in the chemical industry and in medicine and dentistry. Except for osmium, all the platinoids are used to some extent in jewelry.

Given a degree of interchangeability among the platinum-group metals, a continual shifting about in consumption mix occurs with changing relative prices, not only of the platinoid metals themselves, but of gold, silver, and other substitutes. Usage patterns also tend to change rapidly because of the association of these costly metals with high technology industries.

Sources of Platinum

The platinum metals do not deteriorate. It is quite feasible to recover them for reuse unless they become a very small component of widely disseminated products, as is the case with much of the platinum used in electronic equipment. Much of this secondary recovery shows up neither in supply nor in consumption statistics. For example, more than a million ounces a year of the platinoid metals are refined in the United States on behalf of users without furnaces, especially for owners wishing to reclaim spent catalyst. If such amounts were added both to reported U.S. supply and consumption in 1982, the import reliance of the United States would be reduced from 85 percent to 60 percent.

Sources of U.S. platinum-group imports in 1981 are shown in Table 6. South Africa directly supplied the United States with about 80 percent of these imports, plus additional amounts refined in the United Kingdom. South Africa also supplied the United States with about 40 percent of its imports of palladium; the Soviet Union share used to be almost as high but lately has declined. South Africa supplied 70 to 80 percent of ruthenium imports, as well as principal shares of both iridium and rhodium, though the proportions are highly variable. Most of the osmium was refined in the United Kingdom from other countries' ores. Belgium and Luxembourg are also refiners.

A variety of other countries have figured as suppliers of refined platinum-group metals to the United States, but only a few are significant ore producers. Canada is most important among those who also mine these

TABLE 6. SOURCES OF U.S. PLATINOID IMPORTS FOR 1981

Country	Percent of Imports a/	
	By Weight	By Value
South Africa	56.9	67.4
United Kingdom	10.6	11.3
USSR	12.6	6.3
Belgium-Luxembourg	4.9	4.6
Other	15.0	10.4

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1981.

a. Includes imports of refined scrap metals and semimanufactured metal.

metals (as by-products), but Colombia and Japan are also of some consequence.

Nature of the Risks

A handful of mines and an even smaller number of refineries in a concentrated section of South Africa's Transvaal account for about 70 percent of U.S. primary platinoid supply. Much of the rest comes from the Soviet Union. Moreover, the supply of the most acceptable substitute, gold, tends to come principally from the same two countries. Thus, platinum-group metals pose a substantial supply risk.

Beyond the supply risk is the risk of deliberate price escalation. Moreover, both platinum and palladium, and to a lesser extent the other platinoid metals, are prime candidates for price runups through speculation and hoarding, and both respond to the price of gold. Add the substantial control over new supply exercised by South Africa and the Soviet Union, and the market appears to be unduly conducive to price ratchets.

The small number of mine and refinery locations in South Africa suggests an inordinate vulnerability to interdiction of supply by insurrection or sabotage. Concentration of the great bulk of production in the hands of only two companies also suggests a high vulnerability to strikes, as well as to market manipulation. The additional fact that the great bulk of South Africa's platinum is produced for its own sake and not as a by-product lessens any constraint on market manipulation. Gold, not platinum, is the principal source of South Africa's foreign exchange, and gold production adds only a minor amount of platinum coproduct.

A perceived risk from the Soviet Union is that its offerings may be subordinated to political objectives. While evidence to support such a view is scanty, the reason for supply concern is real. The Soviet Union does not always have acute foreign exchange problems, and its sales of palladium are rarely critical to its balance of trade. As a state trader, the Soviet Union can and usually does try to manage the timing and mode of its offerings to maximize long-run commercial advantage. Conceivably, greater domestic need may also contribute to a gradual decline in Soviet offerings. If this happens, the West could adapt relatively easily to such a change.

Since so much of U.S. domestic consumption is now tied to air pollution control, the central risk is that supply curtailment would entail lower air quality standards for some period of time. In addition to the use of platinum in automobile catalytic converters, the platinoids are also used as catalysts to increase refinery yields of high-octane gasoline. In an emergency, more of this could be done with lead. Another catalytic use is to remove sulfur.

In electrical and electronic applications, the platinoids have critical uses. If they were unavailable, the lifetime costs of electrical and electronic goods would increase significantly. Such uses are only a small part of total platinoid consumption, however, and they can easily be satisfied by diversion from other uses. While many applications are in military hardware and a lack of platinoid metals would be a serious impediment to defense production, the amount required is quite small. In general, the overall cost of these military and civilian devices and systems are so high that the value of any contained platinoids, even at a multiple of present prices, would be negligible.

Supply Alternatives

The single most important supply alternative for the platinoids is the stock of metal already in use. This includes the world's stock of jewelry, much of which might become more valuable to its owners as scrap than as heirlooms or objets d'art if platinum prices were to soar. In an all-out emergency, the stock of platinum, palladium, and rhodium in the automotive fleet's catalytic converters should be included. Converters in scrapped cars have begun to accumulate, and before long will be routinely processed. Inventories of the platinoid metal held in the form of industrial catalysts are already routinely recycled. They would become an important source if, in an emergency, it were decided to forgo some of the functions they now perform.

Large inventories of palladium, in particular, are carried in the strategic stockpile (holdings are about 40 percent of goal). The amount on hand is close to a year and a half of normal consumption--a large supply for essential use. Government holdings of platinum are equal to less than a half-year of normal consumption, but known commercial stocks add another half-year. Known commercial stocks of palladium equate to about four months of normal consumption. Stocks of rhodium and ruthenium would meet normal consumption for the better part of a year. Stocks of iridium are well in excess of recent annual rates of consumption, although consumption is highly volatile. Stocks of osmium fluctuate considerably, but at recent levels exceed a year's consumption.

Finally, increased primary production is possible in a number of areas outside South Africa, and this would automatically be called forth by rising prices. Rising prices would also stimulate increased sales from the Soviet Union, unless the cause of the South African interruption were an East-West military confrontation.

The United States is one possible source of additional mine production. The Stillwater complex in Montana contains deposits of platinum and palladium, as well as of chromite. Platinoids are already recovered as a by-product of copper production elsewhere in the United States. They have been produced in the past from deposits in Alaska, and these could be reactivated. They might also be extracted from beach sands in Oregon.

Canada has platinoid metals, particularly in association with Sudbury nickel; production would be increased if nickel prices were higher. Canada also has other platinoids associated with nickel and copper production, as well as a near-economic deposit in which the platinoid metals are themselves of primary interest. Other probably expandable sources include Colombia, where platinoid metals are produced as a coproduct with gold, and the nickel mines of Australia, where the platinoid metals are produced as a by-product.

Consumption Alternatives

The principal consumption alternative is conservation, particularly in jewelry. Jewelry probably accounts for nearly half the total use of platinum in market-economy countries worldwide, thus providing large leeway for diversion to more critical applications in a supply emergency. Alternatives for the platinoid metals are restricted because the principal substitute is gold, which would probably also be in short supply during a platinum-group contingency, given their common producers and applications. The flow of gold, however (especially from hoarded supplies), would be stimulated by the upward pressure of platinoid shortages on gold prices.

Apart from gold, silver and tungsten are substitutes for the platinoids in electrical uses. Ceramics may be substituted in dental restitutions, and plastics in this and other kinds of prothesis. Rare-earth metals, nickel, vanadium, and titanium are possible substitutes in catalytic uses. Over a long period of readjustment, engineering improvements and cleaner fuels (both, of course, at a price) could diminish the need for the platinum-group metals in automotive emission control.

Conclusions

The extremely high concentration of platinoid supply in South Africa and the Soviet Union renders this group of metals one of the most critical of all potential mineral contingency problems, both in terms of supply interruption and deliberate price escalation. Price rises would provide much of the solution to any crisis, leading to the selling of hoarded items (especially of jewelry), large-scale diversion of platinoid consumption from less essential uses, and expansion of alternative production. Furthermore, the most essential uses tend to be those that can most readily bear heightened platinoid costs, because the platinoids are only a small part of overall costs.

Critical applications of the platinoids in ensuring lasting high performance of essential civilian and military systems require only a relatively small proportion of the total supply. A further broad area of consumption needs can be satisfied by available substitute materials, and a still broader area of consumption can be curtailed, if necessary by law.

Given such options, the stockpiled quantities of platinum, palladium, and iridium seem more than adequate to provide for necessary transitions during a military conflict, even at current small percentage-of-goal levels. Bringing the stockpile up to goal would cost more than $550 million--about $350 million for platinum, $200 million for palladium, and a small additional amount for iridium.

CHAPTER IV. ANALYSIS OF SELECTED BULK MINERALS

The metals discussed in the preceding chapter were selected for their critical industrial and defense uses and the near total U.S. dependence on imported supply. The ones discussed in this chapter were selected because of the volume of their use in the U.S. economy and international competition for their supplies. They are the four major nonferrous metals that enter ubiquitously into the country's durable goods and structures. Recent consumption of aluminum has been at the rate of 5 to 6 million tons a year and is certain to go higher. Copper, which used to be the highest volume nonferrous metal, is now consumed at about 2 million tons a year. Lead and zinc are each in the million-ton-per-year range, about the same as manganese.

The problems posed by copper, lead, and zinc depend less on security of supply than on international competitiveness. A large number of Americans depend for their livelihoods on their mining, smelting, and refining. Among the minerals discussed in the preceding chapter, by contrast, direct employment is small and security of supply is the overriding factor.

All four of these metals are now traded on international commodity exchanges (copper, lead, and zinc for many years; aluminum only recently). Prices fluctuate widely, mostly with the state of the world industrial economy, whose condition has depressed the nonferrous metals industry for several years. In addition, the domestic smelting and refining industry has had to contend with aging plants and—especially onerous for lead and zinc—the need to comply with new pollution-control standards. Foreign competitors, to a large degree, have newer processing plants, a lesser concern with pollution, and, in the case of producers in the less developed countries (LDCs), an overriding interest in maintaining employment and the flow of foreign exchange even if it means continuing to produce at an economic loss.

ALUMINUM

The United States consumed 5.1 million tons of aluminum in 1981. Net imports of the metal were essentially nil, but 97 percent of the necessary bauxite and alumina were imported at a cost of about $1 billion. The price of aluminum decreased gradually during the post World War II period and aluminum took over a good part of the markets formerly served by steel, copper, lumber, and zinc (galvanized iron).

The advent of OPEC changed public concerns remarkably. With an average of around eight kilowatt hours of electricity incorporated into the manufacture of every pound of primary (virgin) aluminum, rocketing fuel costs began to make a big difference in smelter competitiveness, depending upon the type and source of power supply. The other effect of OPEC was to generate a general concern about cartelization. Formation of the International Bauxite Association and the imposition by Jamaica, and then others, of heavy levies on their exports of bauxite heightened the concern. It was feared that aluminum supply and price would be at the mercy of outside suppliers, threatening the U.S. economy and possibly interrupting material supplies for the aerospace industry and other critical users. These concerns have now subsided, but not entirely died out.

Role in the U.S. Economy

Prior to the severe drop in nearly all materials consumption in 1982, occasioned by the worldwide recession, primary aluminum was roughly a $7.5 billion industry. The recovery of secondary aluminum from scrap and the conversion of aluminum into sheets, wire, castings, and other intermediate forms more than doubles that value. 1/ In early 1981, before the recent recession, some 37,000 workers were employed in primary aluminum refining, 35,000 in aluminum rolling mills, and 53,000 in aluminum foundries. 2/ Additional numbers were engaged in the manufacture of aluminum extrusions and aluminum wire, for a total of about 147,000. 3/ This makes aluminum about one-fifth the size of the iron and steel industry and two-thirds as large as all other nonferrous metal production combined.

Little bauxite is mined in the United States. Domestic production of bauxite employed fewer than 500 workers and generated gross revenues of only about $50 million in 1977. 4/ Roughly 97 percent of the feedstock for U.S. aluminum smelters is imported, either as bauxite or as alumina.

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1. See U.S. Department of Commerce, Bureau of Industrial Economics, U.S. Industrial Outlook, 1982, p. 165.

2. Commerce Department, Bureau of Labor Statistics, Employment and Earnings (May 1982).

3. Commerce Department, U.S. Industrial Outlook, 1982, p. 165.

4. U.S. Bureau of the Census, Census of Mineral Industries (1977).

As of the mid-1970s, the United States consumed about 3.5 tons of aluminum per million dollars of gross national product (GNP), and the ratio is still growing. 5/ In terms of weight, this was only about 3 or 4 percent of the amount of steel consumed, but in terms of volume it was around 10 percent and in terms of monetary value, about 15 percent. Moreover, steel's "intensity of use," (the amount of steel needed to make a given amount of real output) has been declining, while that of aluminum has been increasing. Yet it takes less than half a cent's worth of finished aluminum to produce a dollar of GNP. 6/

Uses and Substitutes

Aluminum is employed in such diverse uses as construction, transportation equipment, and containers and packaging. Of the roughly 4.7 million tons of "new" aluminum consumed in 1982, down from a peak of 6.0 million in 1978, approximately 39 percent went into cans and packaging materials, 20 percent into transportation equipment, and 14 percent into construction. 7/ In addition, some 600,000 tons of aluminum contained in bauxite and alumina was diverted into the making of chemicals, refractories, and abrasives or into alumina exports. Although aluminum is also important for the production of military hardware, such as aircraft and missiles, peacetime requirements are only a small part of normal civilian consumption.

Soft-drink and beer cans consume most of the aluminum used in the packaging market. Aluminum now accounts for some 85 percent of the beverage can market, which is still growing. Construction applications include siding, door and window frames, mobile homes, bridge and guard rails, ducting, and many other uses in which aluminum has displaced wood, copper, or steel. Although this use of aluminum was low in relative share as well as absolute volume in 1982 because of the concentrated impact of the recession on the construction industry, its long-term trend is growing.

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5. L.L. Fischman, et al., World Mineral Trends and U.S. Supply Problems, pp. 88, 173.

6. Derived from U.S. Department of Commerce, The Detailed Input-Output Structure of the U.S. Economy: 1972, vol. II (1979).

7. "New" aluminum refers to primary aluminum production plus recovery from scrap. Circulating industrial scrap is omitted.

Aluminum's increasing use in transportation equipment has been spurred by the need for lighter vehicles. It has as yet made only moderate competitive inroads into the passenger-car market. In 1981, automobiles accounted for about half the total amount of aluminum use in the transportation equipment sector, while trucks, buses, and trailers accounted for another one-fourth, and aircraft, vessels, and rail cars for the balance.

Electrical applications have been one of aluminum's fastest growing markets, induced particularly by the use of aluminum in high-voltage transmission lines. This market is relatively saturated. Aluminum will continue to displace steel in transmission towers and copper in other types of wiring, but its prospects in the sizable house-wiring market have been dimmed by alleged safety considerations. Though these have been overcome technically, receptivity to the use of aluminum in this application has yet to be widely revived.

Aluminum's lighter weight no longer gives it clear price advantage over copper on a weight basis. The weight saving is frequently offset by such technical problems as difficulty in soldering. Aluminum still retains some price advantage, however, in that it takes fewer pounds of aluminum to perform any given function. In relation to steel, aluminum's advantage in terms of the costs of material required to perform equivalent functions is mixed, since per pound, steel is usually much cheaper. Moreover, the steel industry is countering aluminum competition with advances such as thinner tinplate. The development of high-strength, low-alloy steel has so far forestalled significant aluminum inroads into the manufacture of automobile bodies. In the future, aluminum will also have to face increasing competition from high-strength (composite) plastics. In general, however, future trend growth in aluminum is likely to continue to be faster than that of steel or of the other three nonferrous metals that this chapter considers.

Sources of Supply

The United States imports nearly 100 percent of its supplies of bauxite and alumina--the feedstocks for smelters that produce unfabricated aluminum metal. Domestic bauxite accounts for only about 5 percent of the metallic aluminum supply. Over the period 1978-1981, 40 percent of the imported bauxite arrived from Jamaica and 28 percent from Guinea, while 76 percent of the alumina originated in Australia. The sources of these imports for 1981 are given in Table 7. Most of the imports still arrive as bauxite and are "refined" into alumina in this country, but the proportion arriving as alumina is increasing. Apart from the desire of most bauxite-producing countries to increase their processing revenues, shipment as alumina eliminates about 60 percent of the original bulk of bauxite ore.

TABLE 7. SOURCES OF U.S. BAUXITE AND ALUMINA IMPORTS FOR 1981

Country	Percent of Bauxite Imports	Percent of Alumina Imports	Approximate Percent of Combined Equivalent
Australia	0.1	74.3	53.1
Jamaica	40.8	13.1	21.0
Surinam	8.5	11.3	10.5
Guinea	27.0	--	7.7
Brazil	9.6	--	2.7
Canada	--	0.9	0.7
Other	14.0	0.4	4.3

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1981.

Sources of supply for bauxite are not wholly interchangeable, since refineries must be adapted to the ore composition. In particular, Jamaican bauxite (a mixed variety) is not readily interchangeable with the African and South American varieties (gibbsite).

Nature of the Risks

Because so much of the bauxite and alumina feedstock for the U.S. aluminum industry comes from Third World countries that are members of the International Bauxite Association, there has been concern about both possible cartelization and security of supply. The fragility of some of the sources is illustrated by difficulties experienced by the Alcoa bauxite subsidiary in Surinam in dealing with the leftist-leaning military regime that recently took over that country.

The U.S. aluminum industry has, however, shown great adaptability in developing alternative sources. Roughly a dozen different countries contribute to U.S. bauxite supply, and there are as many or more untapped bauxite producers. More than ample capacity currently exists around the world to convert bauxite into alumina. Only the sustained resumption of rapid growth in world consumption would begin to produce refinery bottlenecks.

Energy and labor costs and pollution abatement represent the major problems facing the U.S. aluminum industry. The three problems are interrelated inasmuch as rising energy costs have squeezed the margins available for liberal labor settlements and for dealing with pollution. Even the most efficient smelters require 6 kilowatt hours of electricity for each pound of aluminum, and additional energy is required for baking the carbon electrodes. The method of power production and price setting are the two most important determinants of which aluminum smelting capacity will remain competitive and where new capacity will be installed. The rapid increase in natural gas prices in the Southwest has already caused the closing of part of the aluminum smelting industry in that area and will result in further permanent closures. In the Northwest, where most of the electricity is generated by water power, future competitiveness will depend in part on the outcome of a controversy over whether the aluminum companies, which had been accustomed to low-cost, interruptible power, will in the future be charged the same rates as other industrial consumers. In general, however, capacity shutdowns in that area have been mostly a consequence of the recession and obsolescence. With renewed economic growth, the level of operating capacity both in the Northwest and in some other parts of the country is likely to be restored and perhaps expanded.

Future capacity growth in the United States will not be nearly as rapid, however, as either trend growth in U.S. consumption or the growth of smelting capacity elsewhere in the world. Canada is one of the places with a competitive power advantage, and will remain the principal U.S. source of imported aluminum metal. Normally some 15 to 20 percent of the gross supply of the metal form is imported, mostly from Canada. Other countries with competitive advantage include Brazil, Venezuela, Australia, and a number of those in central Africa—one of which, Ghana, is already a significant U.S. supplier.

Depending on the pace of world economic recovery, there is the potential for future sharp rises in the price of aluminum. While trend growth in aluminum consumption will remain strong, the prolonged recession has resulted in delays and cancellations of many previous plans for capacity expansion. Both at the refinery and smelter levels, this could cause future bottlenecks. Given the current outlook for a drawn-out recovery, however, there should be ample time to reactivate expansion plans. Moreover, aluminum price increases should be restricted by competition with alternative materials.

Conclusions

There is little reason for governmental concern with U.S. aluminum supply or the health of the U.S. aluminum industry. The industry has shown considerable resilience even during prolonged recession, discounted prices, and operations averaging only 60 percent of capacity. Current industry stocks of aluminum now stand at about seven to eight months of normal consumption. These levels are considered high and probably will be reduced before much production expansion occurs. The existing capacity margin provides insurance against sharp price rises for some time to come, however.

Despite the importance of aluminum in the production of aircraft, missiles, and other military hardware, peacetime military requirements are low in relation to normal civilian consumption. Mobilization needs are higher, but could readily be satisfied by diversion from less essential uses. Of the stockpile goal of 700,000 tons of aluminum metal, the inventory currently contains only 2,000 tons, and no apparent priority has been given to making up the difference. The goal of about 27 million long tons of metallurgical grade bauxite is about half filled. Since bauxite prices are highly negotiable and barter could be used to acquire part of the ore, it is difficult to estimate costs of filling the inventory goal. About $400 million, including transportation, is a rough estimate. There is no stockpile goal for alumina, presumably because of its poor storage qualities.

COPPER

Copper is the oldest metal used by man and is now second only to aluminum as the most commonly used nonferrous metal. A large part of copper consumption occurs in association with zinc (as in brass) and with tin or lead (as in bronze).

Role in the U.S. Economy

In 1981, before the recession, some 36,000 persons were employed in copper mining and milling, a level that had been maintained for several years. 8/ The smelting and refining phases of the copper industry employed about 12,000 persons. Sustained output of refined copper (primary and secondary) is roughly 2 million tons. 9/ Gross receipts in 1977 were close to $2 billion in the mining phase of the copper industry, 10/ and around

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8. Bureau of Labor Statistics, Employment and Earnings (May 1982).

9. U.S. Department of Commerce, U.S. Industrial Outlook, 1982, p. 157.

10. U.S. Bureau of the Census, Census of Mineral Industries (1977).